Controlled Whole Body Vibration to Decrease Fall Risk and Improve Health-Related Quality of Life of Nursing Home Residents

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ABSTRACT. Bruyere O, Wuidart M-A, Di Palma E, Goulay M, Ethgen O, Richy F, Reginster J-Y. Controlled whole body vibration to decrease fall risk and improve health-related quality of life of nursing home residents. Arch Phys Med Rehabil 2005;86:303-7.

Objective: To investigate the effects of whole body vibration in the elderly.

Design: Randomized controlled trial.

Setting: Nursing home.

Participants: Forty-two elderly volunteers.

Interventions: Six-week vibration intervention plus physical therapy (PT) (n=22) or PT alone (n=20).

Main Outcome Measures: We assessed gait and body balance using the Tinetti test (maximum scores of 12 for gait, 16 for body balance, 28 for global score), motor capacity using the Timed Up & Go (TUG) test, and health-related quality of life (HRQOL) using the Medical Outcomes Study 36-Item Short-Form Health Survey (SF-36).

Results: After 6 weeks, the vibration intervention group improved by a mean ± standard deviation of 2.4±2.3 points on the gait score compared with no score change in the control group ($P<.001$). The intervention group improved by 3.5±2.1 points on the body balance score compared with a decrease of 0.3±1.2 points in the control group ($P<.001$). TUG test time decreased by 11.0±8.6 seconds in the treated group compared with an increase of 2.6±8.8 seconds in the control group ($P<.001$). The intervention group had significantly greater improvements from baseline on 8 of 9 items on the SF-36 compared with the control group.

Conclusions: Controlled whole body vibration can improve elements of fall risk and HRQOL in elderly patients.

Key Words: Accidental falls; Elderly; Quality of life; Rehabilitation; Vibration.

IN COMMUNITY-DWELLING elderly people, falls and fall-related injuries appear to be independent determinants of functional decline.[1] At least 30% of people over the age of 65 years fall each year, and this proportion increases to 40% after age 75.[2,3] Resulting functional limitations significantly predict costs related to physician visits, hospitalizations, mortality, and nursing home admissions.[4] Falls, and even the fear of falling, could also affect health-related quality of life[5,6] (HRQOL). Because muscle weakness and impaired balance are associated with an increased risk of falls in the elderly,[2,3,7] an intervention to prevent these conditions could potentially reduce the frequency of falls.[8]

Controlled whole body vibration is a type of physical therapy (PT) thought to activate muscles via reflexes.[9] Clinical studies suggest that controlled mechanical whole body vibration may improve muscular performance[10-17] and body balance[10] in young, healthy adults. In a 4-month randomized trial of young, healthy, nonathletic adults, 4-minute whole body vibration treatments transiently improved lower-extremity muscle performance and body balance.[10] In a randomized controlled trial (RCT), a 10-day whole body vibration regimen (26Hz; amplitude, 10mm; 10min/d in 2-min intervals) significantly enhanced the explosive power of the lower extremities (height of jump, mechanical power of jump) in physically active subjects.[12] To our knowledge, only 1 study has examined the effects of controlled whole body vibration in elderly people. That study evaluated a 2-month vibration regimen (27Hz; amplitude, 7–14mm; 3×2min, 3 times/wk) for geriatric patients; an 18% decrease in time to rise from a chair was observed in the vibration group compared with no change in the controls.[18] The study did not evaluate the effects of the vibration regimen on specific risk factors for falls.

We performed a prospective RCT to determine whether controlled whole body vibration and PT are more effective than PT alone in elderly nursing home residents. Our primary goal was to assess the effect of treatment on muscular performance and body balance, which are known risk factors for falls in elderly people. Our secondary goal was to investigate the effects of controlled whole body vibration exercises on HRQOL.

METHODS

Participants

Forty-two volunteer nursing home residents aged 63 to 98 years (mean age, 81.9±6.9y) were recruited from a nursing home in Liège, Belgium. Residents were eligible for the study if they were ambulatory and had no major cognitive disorders that would affect their ability to complete a questionnaire. Patients with a high risk of thromboembolism or a history of hip or knee joint replacement were excluded. The patients were randomized to receive the vibration intervention plus a standard PT regimen or PT alone (fig 1).

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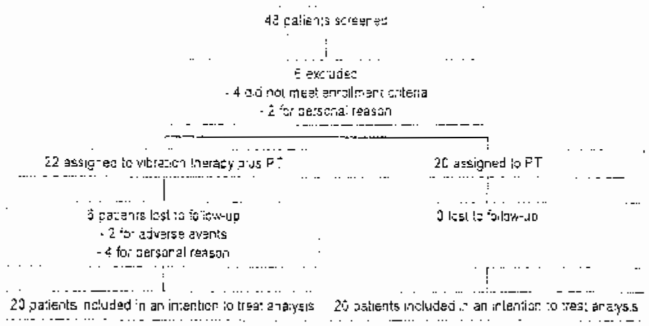

Fig 1. Trial profile.

Controlled Whole Body Vibration Intervention

The treatment intervention consisted of 6 weeks of controlled whole body vibration training. Subjects participated in training sessions 3 times a week; at each session, they stood on a vertical vibrating platform[a] for 4 series of 1 minute of vibration alternating with 90 seconds of rest. Vibration was set at 10Hz for the first and third series, with a peak-to-peak amplitude of 3mm. For the second and fourth series, vibration was set at 26Hz with a peak-to-peak amplitude of 7mm. Blood pressure and pulse were taken before the first series, immediately after the second and fourth series, and 2 minutes after the fourth series in each session.

Physical Therapy

Both groups of patients received PT as maintenance therapy consisting of a standard exercise program (gait and balance exercises, training in transfer skill, strengthening exercises with resistive mobilization of the lower limbs). The PT was administered for 10 minutes, 3 times weekly during the 6-week study period. To ensure consistency, only 1 physical therapist provided the exercise program.

Data Collection

Outcome measures were assessed at baseline and at 6 weeks for all patients. The Tinetti test was used to assess balance and gait abnormalities.[19] This test consists of 16 items: 9 for body balance and 7 for gait. The Tinetti test grades such features as gait speed, stride, symmetry, and balance while standing, turning, and nudging and with eye closure. The score for each exercise ranges from 0 to 1 or 0 to 2, with a lower score indicating poorer physical ability. The global score is the sum of the body balance score and gait score. The maximum score is 12 for gait, 16 for body balance, and 28 for the global score. We assessed functional mobility using the Timed Up & Go (TUG) test,[20] which is a modified version of the Get Up & Go (GUG) test.[21] The patient is asked to rise from a standard armchair, walk to a marker 3m away, turn, walk back, and sit down again. The score is the time in seconds to complete the test. This test is brief and requires no special equipment or training. We measured quality of life (QOL) using the 9 subscales of the Medical Outcome Study 36-Item Short-Form Health Survey (SF-36): physical function, social function, role–emotional, role–physical, mental health, vitality, pain, general health, and health change. The SF-36 consists of 36 multiple choice items in 8 health domains that describe the overall HRQOL as reported by the subject.[22] Four dimensions refer to physical health and 4 dimensions to mental health. All subscales were scored using a Likert scale, with lower scores representing a perception of poorer health, loss of function, and presence of pain. The SF-36 has shown consistently high levels of reliability (test-retest, internal consistency) and validity (content, concurrent, criterion, construct, predictive).[23,24] It has been widely applied and validated for measurement of health outcomes in French-speaking respondents.[25]

Table 1: Baseline Characteristics of Nursing Home Residents Randomized to Whole Body Vibration Plus PT Versus PT Only

	All Randomized Patients			Patients Assessed for 6 Weeks		
Characteristic	Whole Body Vibration Group (n=22)	Control Group (n=20)	P	Whole Body Vibration Group (n=16)	Control Group (n=20)	P
Age (y)	84.5±5.9	78.9±6.9	.03	83.6±4.8	78.9±6.9	.08
Women (%)	81	65	.22	92	65	.06
Medical conditions (% by self-report)						
Osteoarthritis	72	60	.38	64	60	.80
Osteoporosis	31	30	.89	29	30	.93
History of cardiac diseases	27	35	.59	21	35	.39
SF-36 scores (/100)						
Physical function	27.3±21.8	30.8±30.8	.92	21.3±16.0	30.8±30.8	.67
Social function	63.3±18.6	66.5±22.8	.82	68.9±22.0	66.5±22.8	.79
Role–physical	53.8±33.7	53.9±34.6	.99	60.4±31.0	53.9±34.6	.59
Role–emotional	45.0±34.6	50.9±42.1	.65	55.6±35.8	50.9±42.1	.79
Mental health	47.8±15.2	47.4±24.1	.70	48.3±16.7	47.4±24.1	.73
Vitality	39.3±16.2	40.0±26.4	.82	37.1±16.2	40.0±26.4	.99
Pain	56.3±16.1	50.1±31.6	.31	58.5±13.5	50.1±31.6	.24
General health	54.0±13.9	56.3±25.7	.78	54.2±8.5	56.3±25.7	.77
Health change	46.3±23.3	39.5±17.3	.51	43.8±15.5	39.5±17.3	.73
Tinetti test score						
Balance (/14)	8.7±3.9	10.3±3.5	.22	8.6±3.6	10.3±3.5	.29
Gait (/16)	6.2±2.8	7.8±3.2	.14	6.1±2.5	7.8±3.2	.13
Total (/28)	14.9±6.1	18.0±6.2	.16	14.6±5.2	18.0±6.2	.15
TUG test score (s)	36.1±16.2	31.3±29.9	.04	36.4±16.3	31.3±29.9	.04

NOTE. Values are mean ± SD.

Table 2: Change in SF-36 Scores After 6 Weeks in the Whole Body Vibration Group and Control Group (ITT analysis)

SF-36 Scores	Whole Body Vibration Group (n=22)	Control Group (n=20)	P
Mean increase in SF-36 scores (/100)			
Physical function	18.5 ± 13.9	2.4±11.6	<.001
Social function	19.9±17.6	-2.6±17.5	<.001
Role–physical	36.3±30.9	–5.2±29.6	<.001
Role–emotional	31.7±38.2	1.7±34.2	.02
Mental health	10.1±17.1	–2.5±17.8	.03
Vitality	16.0±15.7	–0.8±12.5	.003
Pain	15.2±22.5	–3.6±9.9	.001
General health	11.3±14.3	–8.7±16.8	<.001
Health change	7.5±25.7	0.0±11.8	.24

NOTE. Values are mean ± SD.

Statistical Analysis

Quantitative variables were expressed as mean ± standard deviation (SD), and qualitative variables were reported as absolute or relative frequencies. Differences in baseline characteristics between the 2 groups were assessed using the Mann-Whitney *U* test or Pearson chi-square test when appropriate. Changes in scores for balance, gait, motor capacity, or HRQOL after 6 weeks of treatment were assessed using the Mann-Whitney *U* test. Both intention-to-treat (ITT) and per-protocol analyses were performed. For the ITT analysis, patients who dropped out of the study were invited to receive an evaluation at 6 weeks. If they refused, we used their last available data for the analysis. All analyses were performed with the Statistica, version 6.0 software.[b] Results were considered statistically significant when 2-tailed *P* values were less than .05.

RESULTS

Of the 42 study participants, 22 patients were randomized to the vibration group and 20 to the control group. Baseline characteristics of the 2 groups are summarized in table 1. In the ITT analysis, the treatment group was older than the control group (mean, 84.5y vs 78.9y; $P=.03$) and had a higher mean baseline TUG test time (36.1s vs 31.3s, $P=.04$); all other baseline measures were equal in the 2 groups. In the treatment group, 16 (72.7%) completed the final analysis at 6 weeks, but 20 were included in the ITT analysis. In the control group, all the patients completed the 6-week analysis.

After 6 weeks of treatment (18 sessions), with an ITT analysis, the vibration intervention group showed significantly greater improvement compared with controls on 8 of 9 items from the SF-36 (table 2). Improvement in the gait quality as assessed by the Tinetti test was also observed in the treatment group (score increase, 2.4±2.3) compared with no change in the control group ($P<.001$). Body balance score improved by 3.5±2.1 points in the vibration group compared with a 0.3±1.2–point decline in the control group ($P<.001$). The global score of the Tinetti test increased by 5.6±3.7 points in the treatment group compared with a decrease of 0.3±1.3 points in the control group ($P<.001$) (fig 2). Also at 6 weeks, the treatment group showed a decrease of 11.0±8.6 seconds in their time to perform the GUG test, compared with an increase of 2.6±8.8 seconds in the control group ($P<.001$) (fig 3).

In the per-protocol analysis. 8 of 9 items from the SF-36 showed statistically improvement in the vibration group com-

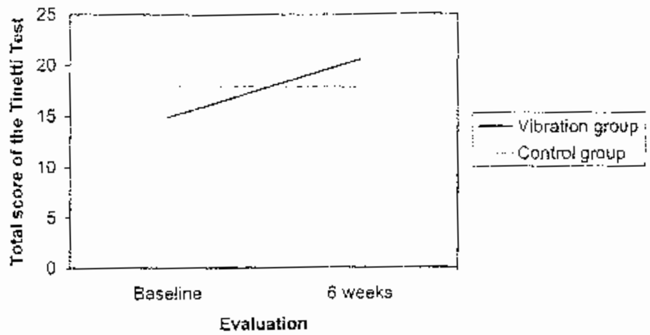

Fig 2. Change in Tinetti global scores in patients assigned to controlled whole body treatment plus PT versus PT only.

pared with the control group. In the vibration group, gait score improved by 2.9 points ($P<.001$), body balance score by 4.5 points ($P<.001$), and total Tinetti score by 7.4 points ($P<.001$). At 6 weeks, the time to perform the TUG test was 13.8 seconds faster in the intervention group compared with controls ($P<.001$).

No serious adverse events (AEs) were observed. Two patients dropped out of the study because of AEs (transient minor tingling of the lower limbs). Changes in blood pressure and heart beat during the sessions were clinically insignificant. Mean pulse was 69 beats/min and mean blood pressure was 135/76mmHg before training. The maximum changes recorded during training were an increase in pulse to 73 beats/min and a decrease in blood pressure to 129/73mmHg.

DISCUSSION

Our study is the first to suggest that a controlled whole body vibration intervention can improve gait. body balance, motor capacity, and self-rated HRQOL in elderly nursing home residents. Controlled whole body vibration improved our participants' muscle strength and balance, which are known risk factors for falls.[2,3,7] At baseline, the intervention group had a mean Tinetti global score of 14.9/28, which was below the threshold (19/28) previously associated with an increased risk of falls.[26] After 18 sessions of whole body vibration, this group slightly surpassed this threshold (mean score increased to 20.5/28). The vast majority of falls are multifactorial, with predisposing long-term and short-term physiologic factors and environmental precipitants.[8] Our intervention addresses an important component of this complex of factors.

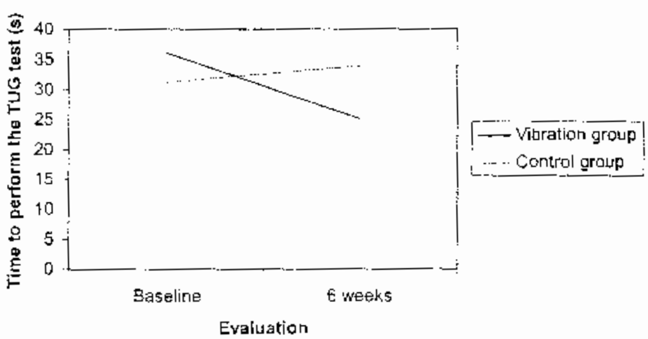

Fig 3. TUG test results in patients assigned to controlled whole body treatment plus PT versus PT only.

The benefits of controlled vibrations could be explained in part by the effects on muscular performance. Most trials of controlled whole body vibration and muscular performance have been conducted in young adults. In 1999, Bosco et al[14] showed that a single vibration training (26Hz; amplitude, 10mm; for 10min in 60-s intervals) resulted in a significant, though temporary, increase in muscle strength in the lower extremities of female volleyball players. Similar increases in maximal and explosive arm and leg strength have been shown in most,[10,13,15-17] but not all[27] studies. Long-term effects of vibration-loading on muscles have also been shown. Increases in jump height and isometric extension strength of lower extremities have been reported in some trials.[11,28] In the elderly population, an 18% decrease in the time to rise from a chair was observed in the vibration group compared with stable values in the control group.[18] Although we did not directly assess muscular performance in the present study, we used the TUG test, which could be considered a surrogate assessment of muscle function. Our results showed significant reduction in the time to perform the TUG test. An increase in body balance could also explain the improvement in this test result. Torvinen et al[10] previously reported a 15.7% improvement in body balance, assessed by a stability platform, after a single 4-minute vibration in young, healthy subjects.

Our study also showed that an intervention using a controlled whole body vibration could substantially improve self-rated global health in elderly patients. The SF-36 has emerged since the early 1990s as a widely accepted, valid, and reliable tool to assess HRQOL.[22] Nearly all items in this instrument improved with the vibration intervention; notably, the physical function measure correlated well with the TUG test. Only the health change item on the SF-36 did not show a change from baseline in the treatment group. This is understandable because this question compares current health with health status 1 year before.

After randomization and before intervention, age and the TUG test differed between the 2 groups. Patients with greater age have been reported to experience a more rapid decrease in their QOL.[29] Despite their older age, members of the treatment group showed substantially greater improvements compared with controls. Controlled whole body vibration appeared to be safe and was well tolerated by the elderly study participants.

CONCLUSIONS

Short training sessions using controlled whole body vibration 3 times a week for 6 weeks improved gait, body balance, motor capacity, and self-reported QOL in elderly nursing home residents. Larger studies with longer follow-up are needed to assess the lasting impact of these benefits.

References

1. Tinetti ME, Williams CS. The effects of falls and fall injuries on functioning in community-dwelling older persons. J Gerontol A Biol Sci Med Sci 1998;53:M112-9.
2. Tinetti ME, Speechley M, Ginter SF. Risk factors for falls among elderly persons living in the community. N Engl J Med 1988;319:1701-7.
3. Nevitt MC, Cummings SR, Kidd S, Black D. Risk factor for recurrent nonsyncopal falls: a prospective study. JAMA 1989;261:2663-8.
4. van Weel C, Vermeulen H, van den Bosh W. Falls, a community perspective. Lancet 1995;345:1549-51.
5. Suzuki M, Ohyama N, Yamada K, Kanamori M. The relationship between fear of falling, activities of daily living and quality of life among elderly individuals. Nurs Health Sci 2002;4:155-61.
6. Scaf-Klomp W, Sanderman R, Ormel J, Kempen GI. Depression in older people after fall-related injuries: a prospective study. Age Ageing 2003;32:88-94.
7. Hausdorff JM, Rios DA, Edelberg HK. Gait variability and fall risk in community-living older adults: a 1-year prospective study. Arch Phys Med Rehabil 2001;82:1050-6.
8. Tinetti ME. Preventing falls in elderly persons. N Engl J Med 2003;348;42-9.
9. Rittweger J, Beller G, Felsenberg D. Acute physiological effects of exhaustive whole-body vibration exercise in man. Clin Physiol 2000;20:134-42.
10. Torvinen S, Kannus P, Sievänen H, et al. Effect of a vibration exposure on muscular performance and body balance. Randomized cross-over study. Clin Physiol Funct Imaging 2002;22:145-52.
11. Torvinen S, Kannus P, Sievänen H, et al. Effect of four-month vertical whole body vibration on performance and balance. Med Sci Sports Exerc 2002;34:1523-8.
12. Bosco C, Cardinale M, Tsarpela O, Colli R, Tihanyi J, Von Duvillard S. The influence of whole body vibration on the mechanical behaviour of skeletal muscle. Biol Sport 1998;153:157-64.
13. Bosco C, Cardinale M, Tsarpela O. Influence of vibration on mechanical power and electromyogram activity in human arm flexor muscles. Eur J Appl Physiol 1999;79:306-11.
14. Bosco C, Colli R, Introini E, et al. Adaptive responses of human skeletal muscle to vibration exposure. Clin Physiol 1999;19:183-7.
15. Bosco C, Iacovelli M, Tsarpela O, et al. Hormonal responses to whole-body vibration in men. Eur J Appl Physiol 2000;81:449-54.
16. Issurin V, Liebermann D, Tenenbaum G. Effect of vibratory stimulation training on maximal force and flexibility. J Sport Sci 1994;12:561-6.
17. Issurin V, Tenebaum G. Acute and residual effects of vibratory stimulation on explosive strength in elite and amateur athletes. J Sport Sci 1999;17:177-82.
18. Runge M, Rehfeld G, Resnicek E. Balance training and exercise in geriatric patients. J Musculoskeletal Interact 2000;1:61-5.
19. Tinetti ME. Performance-oriented assessment of mobility problems in elderly patients. J Am Geriatr Soc 1986;34:119-26.
20. Podsiadlo D, Richardson S. The Timed "Up & Go": a test of basic functional mobility for frail elderly persons. J Am Geriatr Soc 1991;39:142-8.
21. Mathias S, Nayak US, Isaacs B. Balance in the elderly patient: the "get-up and go" test. Arch Phys Med Rehabil 1986;67:387-9.
22. Ware JE, Krinstin KS, Kosinski M, Gandek B. SF-36 Health Survey. Manual and interpretation guide. Boston: New England Medical Center, The Health Institute; 1993.
23. Ware JE. The SF-36 Health Survey. In: Spilker B, editor. Quality of life and pharmacoeconomics. 2nd ed. Philadelphia: Lippincott-Raven; 1996. p 337-45.
24. McHorney CA, Ware JE, Lu JF, Sherbourne CD. The MOS 36-item Short-Form Health Survey (SF-36): III. Tests of data quality, scaling assumptions, and reliability across diverse patient groups. Med Care 1994;32:40-65.
25. Leplège A, Ecosse A, Verdier A, Perneger T V. The French SF-36 Health Survey: translation, cultural adaptation and preliminary psychometric evaluation. J Clin Epidemiol 1998;51:1013-23.

26. Tinetti, ME, Williams TF, Mayewski R. Fall risk index for elderly patients based on number of chronic disabilities. Am J Med 1986; 80:429-34.
27. Torvinen S, Sievänen H, Järvinen TA, Pasanen M, Kontulainen S, Kannus P. Effect of 4-min vertical whole body vibration on muscle performance and body balance: a randomized cross-over study. Int J Sports Med 2002;23:374-9.
28. Torvinen S, Kannus P, Sievänen H, et al. Effect of 8-month vertical whole body vibration on bone, muscle performance, and body balance: a randomized controlled study. J Bone Miner Res 2003;18:876-84.
29. Demura S, Sato S. Relationships between depression, lifestyle and quality of life in the community dwelling elderly: a comparison between gender and age groups. J Physiol Anthropol Appl Human Sci 2003;22:159-66.

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